Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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(54) Optical repeaters

(57) An undersea optical repeater includes a pressure resisting bulkhead through which an incoming sea cable is glanded, interconnecting optical fibres, stored in an elongate compartment within the repeater interconnected the cable with an optical transmitter (laser L1), a receiver (diode D) A rescue laster L2 is provided.

A plurality (A,B,C,D) of such repeaters may be provided in a single pressure-resisting casing (Fig. 3 not shown).

Fig.2.

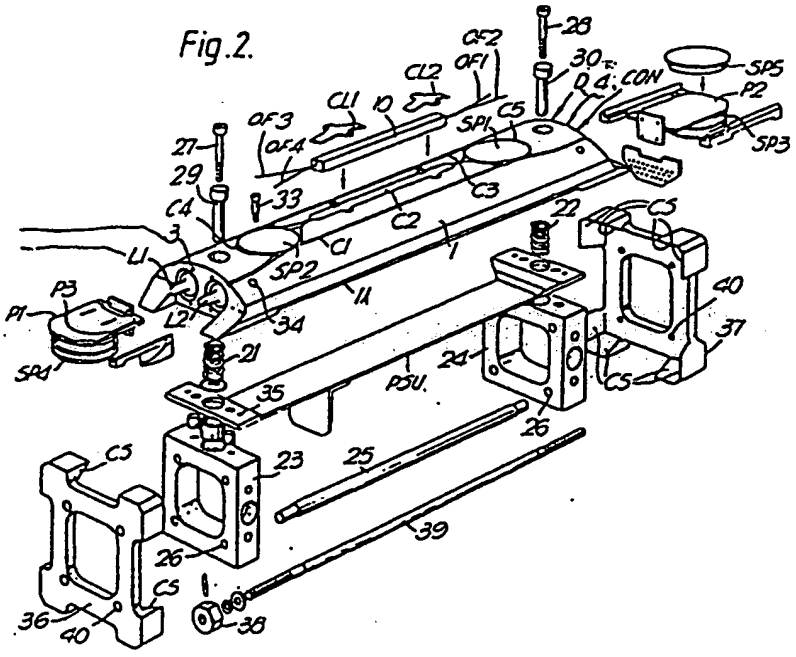

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Fig.1.

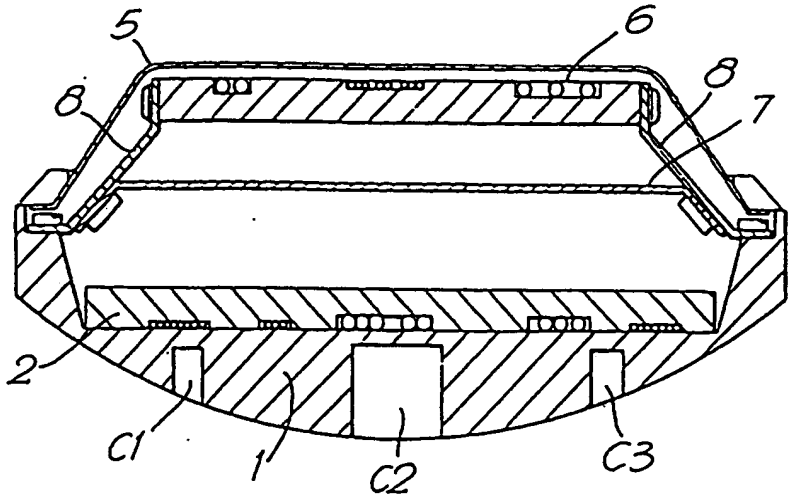
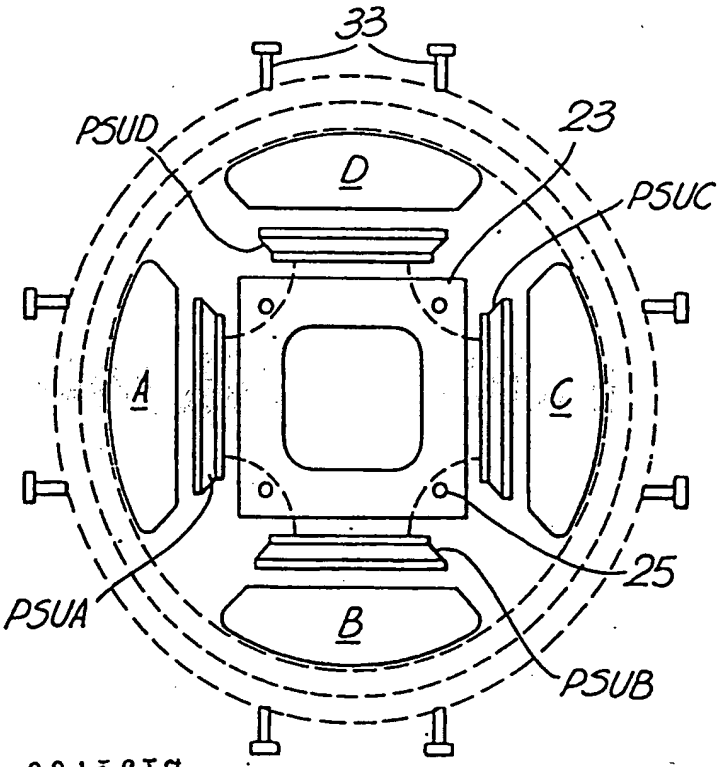


Fig.3.



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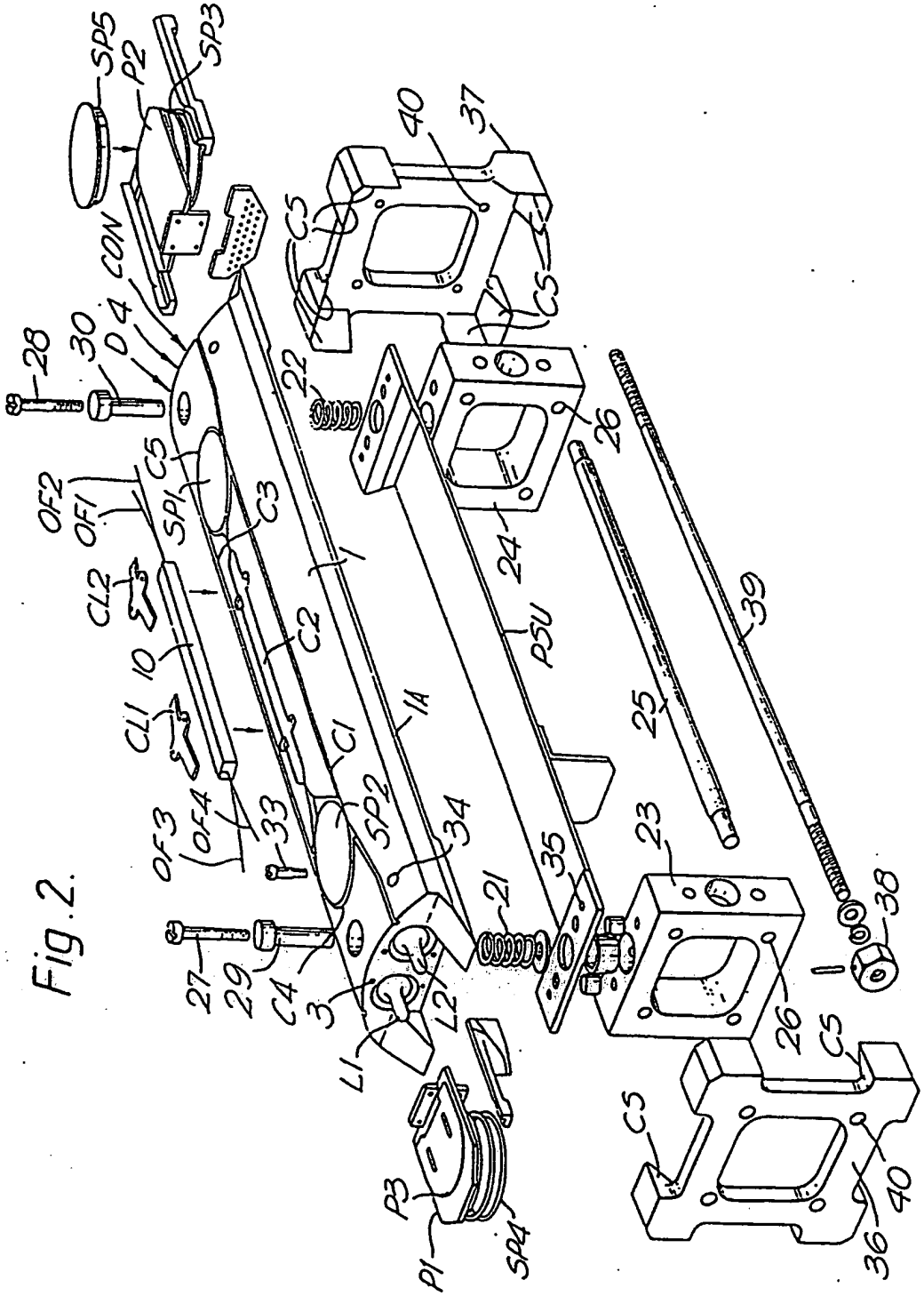


Fig. 2.

Fig. 4A.

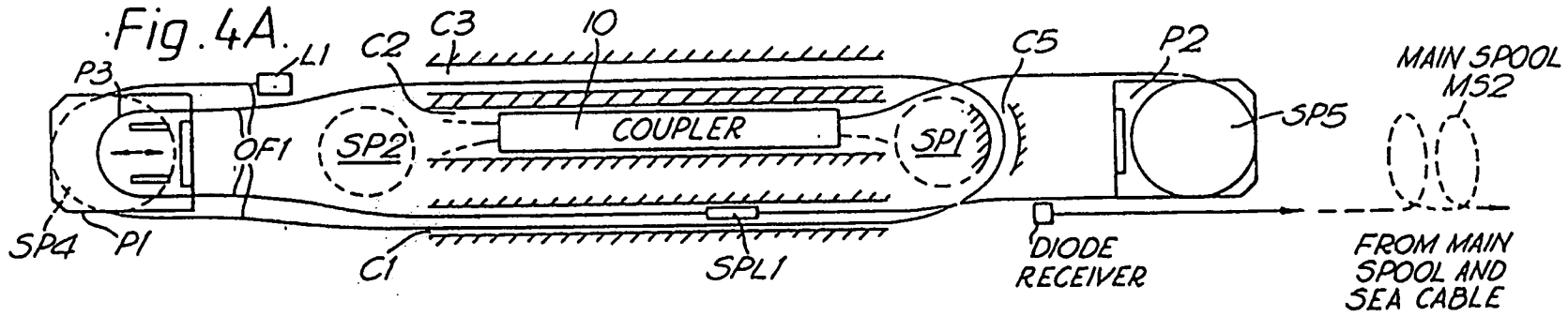


Fig. 4B.

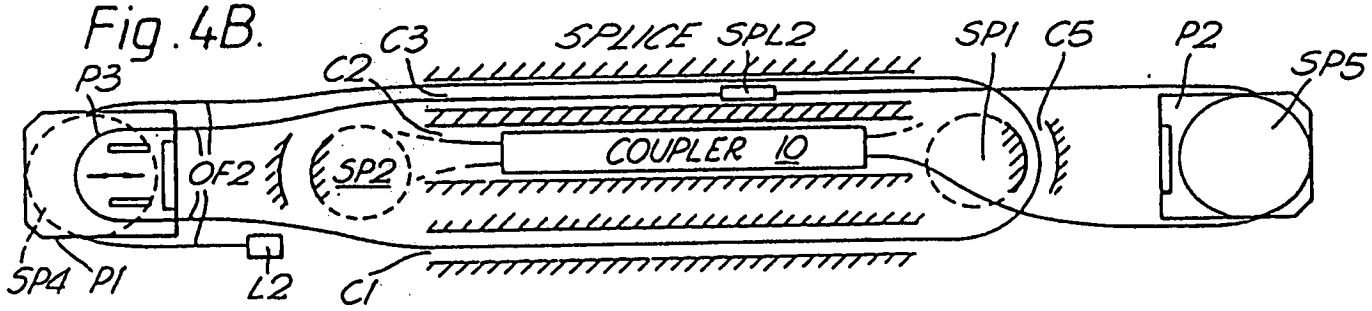
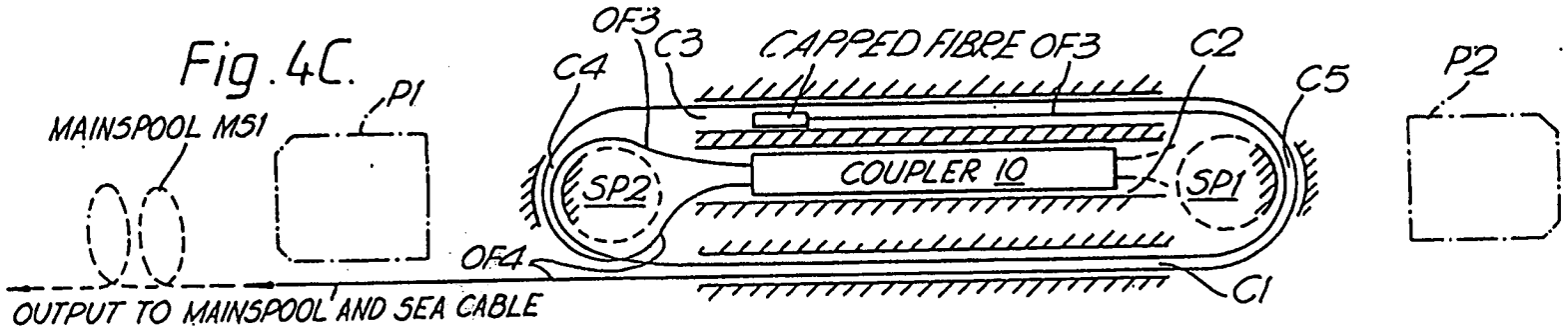


Fig. 4C.



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SPECIFICATION

Optical repeaters

This invention relates to optical repeaters, particularly but not exclusively undersea optical repeaters.

In an undersea optical repeater it is necessary to make splices within the repeater housing particularly between the incoming fibres from the submarine cable and the fibre tails of the opto-electronic transmitters and receivers in the repeater. A difficulty that occurs arises from the need to ensure that the opto-electronic is well protected both from the seabed pressures and from the water and it is thus necessary to devise sealing arrangements where the incoming sea cable enters the repeater housing (primary casing) and if necessary where the individual fibres and power feed penetrate secondary casings on bulkheads within the housing, providing a secondary defence against ingress of moisture. Our British Patent 2058484B (C.S. Parfree 10-7-2) discloses such a bulkhead seal and our pending British Application 2153159A (D.A: Gunn et al) describes an improved arrangement.

In providing the splices and the seals in the repeater it becomes necessary to find room for excess fibre.

It is also necessary to provide a means of cooling the internal chassis so that the electronic and particularly the opto-electronic components are maintained within temperature limits, particularly an upper limit, because the long term performance and reliability of these components is directly related to the temperature at which they operate. The higher the temperature the shorter the period over which they will operate within preset limits. Our British Patent Application 2153151A (A. Davies 3-2) shows ways of doing this but has proved to be expensive. Furthermore US Patent 4528615 shows an alternative arrangement.

It is sometimes desirable to provide for possible failure of parts of the system and in this respect the most vulnerable component is the transmission device which in the current state of the art is an injection laser. It is proposed therefore to provide a standby laser and means to switch in that laser should it ever become necessary.

It is an object of the present invention to provide a repeater construction which enables the above problems to be minimised if not eliminated in a cost effective way.

According to the present invention there is provided a repeater for regenerating an optical signal in an optical transmission system and comprising a repeater housing, an optical transmission device for transmitting the regenerated signal, an optical receiving device for receiving the signal to be regenerated, and a pressure-resisting bulkhead through which an incoming sea cable is or can be glanded and interconnecting optical fibre located within the repeater interconnecting one of said devices with said sea cable and stored in an elongate compartment extending generally lengthwise within the repeater housing.

According to another embodiment of the invention there is provided a repeater for regenerating optical signals in an optical transmission system comprising a housing, a plurality of regenerator modules each of which extends lengthwise within the housing and each of which is urged towards an electrically insulating liner on the internal surface of the casing to provide a heat transfer path for maintaining the modules within a limited temperature range, and an elongate compartment formed by an arrangement of spools and guides as a channel or channels in the outwardly facing surface of the regenerator module.

According to a further aspect of the present invention there is provided a repeater for regenerating signals in an optical transmission system, said repeater having a first optical transmission device and a second optical transmission device an optical coupler, and lengths of optical fibre coupling both devices via the coupler to a fibre of the system, and means for remotely selecting one of the fibres for operation, said coupler and associated coupling fibre being located in an elongate compartment formed by a system of guides and spools arranged to keep the fibre under gentle tension.

In order that the invention can be clearly understood reference will now be made to the accompanying drawings in which:-

Fig. 1 shows a section through a regenerator module, according to an embodiment of the invention,

Fig. 2 shows a general assembly schematic of a regenerator module of Fig. 1 and parts associated with other regenerator modules of the repeater according to the embodiment,

Fig. 3 shows schematically the outline arrangment of the four regenerator modules of Figs. 1 and 2, and

Figs. 4A to 4C show optical wiring diagrams of the stowed fibre.

Referring to Figs. 1 and 2 a regenerator module comprises a base section 1 of mild steel or any conductive material e.g. brass aluminium ceramic, and a lower chassis 2. End plates 3 and 4 which are not shown in Fig. 1 but can be seen at one end in Fig. 2, are integral with the base and close the ends of the regenerator module and a thin mild steel cover 5 seals against the base section and the end plates to provide a sealed regenerator module which is segment-shaped.

Within that sealed enclosure is located an upper chassis 6 and an intermediate plate 7, the upper chassis 6 and the intermediate plate 7 being supported by side plates 8. The chassis 6 and 2 could instead be printed circuit

boards carrying substrates in a simplified version.

The base section 1 has three parallel channels C1, C2 and C3 which can be seen more clearly in Fig. 2. These channels also extend around inner spools SP1, SP2 and thus form an elongate figure-of-eight configuration with the central section C2 enlarged and circular end portions C4 and C5.

An optical coupler 10 is held by clamps CL1, CL2 which allow movement under thermal expansion or contraction.

Two optical transmitters in the form of semiconductor injection lasers L1 and L2 are sealingly mounted in one end plate 3, and an optical receiver D in the form of a semiconductor photodiode and multiway connector CON are mounted in the other end plate 4 in exactly the same way as the (visible) lasers. The connector CON provides an hermetic feedthrough for electrical signals between the regenerator modules.

Referring to Fig. 4A optical fibre OF1 extends from the first laser L1 several times around the spool SP4 which is mounted on plate P1, in turn supported on the end plate 3, along channel C1, around channel C5 and along channel C3, around curved plate P3, back along channel C1, around end spool SP5 and to the coupler 10. A splice in the fibre between the portion integral with the coupler 10 and the remainder constituting the tail of the laser L1, is located in channel C1.

The diode receiver D has a tail which extends directly to a main spool MS2 and on to the sea cable via bulkhead glands.

Referring to Fig. 4B the second laser L2, which is a "redundant" laser and is only switched into service should the laser L1 fail, is connected by optical fibre OF2 around another portion of spool SP4, along channels C3, C5 and C2, around a second groove in a second plate P3' which is independent of plate P3 so that fibres OF1 and OF2 can be tensioned independently and via a splice SPL2 around spool SP5 to the second part of the coupler 10.

Spool SP3 stows fibre from the receiver to ensure no breakages, although it is optional and can in fact be replaced by jigs during manufacture of the repeater.

Fig. 4C shows the output port fibres OF3, OF4 from the coupler 10 being located in the various channels and this time only around the inner spools SP1 and SP2 and the channels C1 and C3, in opposite directions, the fibre OF3 being capped at its end to absorb any signal which it carries. The channels and spools ensure that the fibres are held at a bend radius greater than 30mm and have sufficient capacity to accommodate the spare fibre required for the making of splices SPL1 and SPL2 and for accomodating the splices. Any slack in the optical fibre between a splice and the coupler is taken up by the plates P3 and P3' mounted on plate P1, because the plates P3 and P3' can slide on the plate P1.

The sea cable is sealed through the repeater bulkheads in a primary seal similar to that disclosed in our British Patent 2058484B (C.S. Parfree 10-7-2) referred to earlier and the secondary sealing is accomplished by a technique as described in our British Patent Application No. 2153159A referred to earlier.

Although only one module is shown in Fig. 2 there are in fact four such modules as shown schematically in Fig. 3. Each module is resiliently biassed radially outwardly by springs such as 21 and 22. Frame member 23 and 24 are rigidly held in spaced apart relationship by long tubes such as 25 with a stepped section at each end. The stepped sections are assembled into holes such as 26 and welded or bonded with adhesive. The modules are held to the frame member by screws such as 27 and 28 which are located within electrially insulating guide sleeves 29 and 30 and cups 29A and 30A respectively and which screw into threaded holes in the frame members 23 and 24. When assembled each module is biased outwardly by the springs 21, 22 acting in underside annular recesses in the module and in the cups 29A, 30A, which insulate the springs. The sleeves and cups provide low voltage electrical isolation between regenerator modular segments.

On the underside of each module is an associated power supply unit PSU attached by screws such as 33 which pass through holes 34 into threaded holes 35 in the PSU.

End clamps 36 and 37 have cam surfaces CS in the form of ramps at all four corners and these co-operate with mating cam surface CS1 in the form of ramps which project longitudinally outwardly from the modules. The end clamps are drawn together with nuts 38 on studs 39 passing through holes 40 and the action of the ramps draws the modules radially inwards until spacers such as 41 engage both the frames 23 and 24 and the undersides of the sections 1. The complete regenerator assembly is spliced to the power feed (not shown) and optical fibres of the sea cables are inserted in the tubular lined sea case (the lined case is discussed in detail in our co-pending patent case (IS9509 I.D. Andrews) and the screws 38 slackened so that the clamps 36, 37 move longitudinally outwards so releasing the modules which move radially outwardly under the action of the springs and engage the liner in the sea case.

Referring to Fig. 3 there is shown schematically the four modules, each as described in Figs. 1, 2 and 4 and designated A, B, C and D located each above its respective power supply unit PSU A, PSU B, PSU C, PSU D. Electrical interconnection which is complex is indicated schematically each being supplied electrically in parallel by the dashed line, each segment being effectively isolated from each

other and gas discharge tubes being used to give a path through the regenerator should a cable surge occur. PSU A receives power from the power feed from the sea cable.

The frame members such as 23 support the modules. The modules can be removed to give access to the power supply units by means of screws such as 33. The clamp members 36 are not shown for clarity.

An important advantage of the present invention is the provision of an optical coupler to enable switching of a "redundant" laser so that for each fibre of the system a second laser is available for service, and in such manner that each module, such as A, B, C or D, is completely self-contained as a unitary assembly. This enables complete testing both optically, electrically and mechanically before it is assembled with the other modules into the sea casing. This advantage is provided jointly by the unique fibre and coupler stowage arrangement and by the unique assembly and construction whereby the modules are urged against the casing for both clamping in place and for heat management.

A suitable coupler 10 is described in our British Patent Application 2038017.(T. Bricheno 3).

CLAIMS

1. A repeater for regenerating an optical signal in an optical transmission system and comprising a repeater housing, an optical transmission device for transmitting the regenerated signal, an optical receiving device for receiving the signal to be regenerated, and a pressure-resisting bulkhead through which an incoming sea cable is or can be glanded and interconnecting optical fibre located within the repeater interconnecting one of said devices with said sea cable and stored in an elongate compartment extending generally lengthwise within the repeater housing.

2. A repeater as claimed in claim 1, wherein said elongate compartment is provided by a channel formed in an outer surface of the casing of a regenerator for regenerating the signal in one of the fibres of the system.

3. A repeater as claimed in claim 2, wherein said channel communicates with a spool around which the fibre is or can be wound.

4. A repeater as claimed in claim 3, wherein said channel communicates with a sliding plate which is moveable towards and away from said channel to take up slack in the fibre.

5. A repeater for regenerating an optical signal in an optical transmission system comprising a tubular pressure-resisting casing and a number of regenerator modules extending generally lengthwise within the casing and containing electronic and opto-electronic devices for regenerating the optical signal in respective optical fibres of the system, a framework centrally disposed within the casing, and resilient biassing means urging each moudle radially outwardly from the framework into heat-transfer-contact with the casing.

6. A repeater as claimed in claim 5, wherein the casing has an electrically-insulating internal liner which electrically insulates the modules from the casing.

7. . A repeater as claimed in claim 5 or 6, comprising a clamping arrangement which engages each of the modules and has cam surfaces cooperating with the modules, said arrangement being adjustable to draw the modules radially inwardly against the resilient bias means so that the modules can be longitudinally inserted into or withdrawn from the casing.

8. A repeater as claimed in claim 7 wherein said cam surfaces comprise for each module a ramp projecting from each end, and said clamping arrangement comprises a pair of clamp members common to the modules and having for each module a cooperating ramp, there being a screw device for moving the clamp member relative to the modules to draw the modules radially inwards.

9. A repeater for regenerating optical signals in an optical transmission system comprising a housing, a plurality of regenerator modules each of which extends lengthwise within the housing and each of which is urged towards an electrically insulating liner on the internal surface of the casing to provide a heat transfer path for maintaining the modules within a limited temperature range, and an elongate compartment formed by an arrangement of spools and guides as a channel or channels in the outwardly facing surface of the regenerator module.

10. A repeater for regenerating signals in an optical transmission system, said repeater having a first optical transmission device and a second optical transmission device an optical coupler, and lengths of optical fibre coupling both devices via the coupler to a fibre of the system, and means for remotely selecting one of the fibres for operation, said coupler and associated coupling fibre being located in an elongate compartment formed by a system of guides and spools arranged to keep the fibre under gentle tension.

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